National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 23, 2009

In reply refer to: R-09-8 and -9

The Honorable Peter M. Rogoff
Administrator
Federal Transit Administration
1200 New Jersey Avenue, SE
East Building
Washington, D.C. 20590

On May 28, 2008, about 5:51 p.m., eastern daylight time, westbound Massachusetts Bay Transportation Authority (MBTA) Green Line train 3667, traveling about 38 mph, struck the rear of westbound Green Line train 3681, which had stopped for a red signal. The accident occurred in Newton, Massachusetts, a suburb of Boston. Each train consisted of two light rail trolley cars and carried two crewmembers—a train operator at the front of the lead car and a trail operator in the second car. The operator of the striking train was killed; the other three crewmembers sustained minor injuries. An estimated 185 to 200 passengers were on the two trains at the time of the collision. Of these, four sustained minor injuries, and one was seriously injured. Total damage was estimated to be about $8.6 million.[1]

The National Transportation Safety Board (NTSB) determined that the probable cause of the May 28, 2008, collision of two Massachusetts Bay Transportation Authority Green Line trains in Newton, Massachusetts, was the failure of the operator of the striking train to comply with the controlling signal indication, likely as a result of becoming disengaged from her environment consistent with experiencing an episode of micro-sleep. Contributing to the accident was the lack of a positive train control system that would have intervened to stop the train and prevent the collision.

The accident occurred near the western terminus of the MBTA's Green Line, between the Waban and Woodland stations. These stations are about 4,300 feet apart, and the trip between them, under normal conditions, takes anywhere from 73 seconds to 2 minutes.

Crewmembers of the struck train reported nothing out of the ordinary during their afternoon run until about 5:50 p.m., when the train operator observed that signal H-66, about

[1] For more information, see <http://ntsb.gov/publictn/2009/RAR0902.pdf>. *Collision Between Two Massachusetts Bay Transportation Authority Green Line Trains, Newton, Massachusetts, May 28, 2008,* Railroad Accident Report NTSB/RAR-09/02 (Washington, DC: National Transportation Safety Board, 2009).

1,666 feet west of Waban station, was displaying a single red aspect. MBTA rules state that a train encountering such a signal must stop and hold short of the signal for 1 minute before proceeding at restricted speed not to exceed 10 mph while being prepared to stop short of a car, train, or other obstruction.

The presence of train 3681 caused signal H-64, just outside Waban station, to also display a red aspect. Seeing this aspect, the operator of train 3667 should have held short of signal H-64 for 1 minute before proceeding at a speed not to exceed 10 mph while looking out for other trains or obstructions. According to the trail operator of the striking train, on the day of the accident, the train served the station normally. He did not indicate that the train held at the station any longer than usual. Instead, he said the train began to accelerate normally out of the station.

Operating the train after the station stop would have required that the operator wait until the doors were closed and then, while depressing the dead man pedal, move her right foot from the brake pedal to the accelerator pedal. She must have performed these actions on the day of the accident without waiting the required 1 minute, in violation of the signal indication being displayed by signal H-64.

If the operator had simply failed to observe or note the red aspect at signal H-64, she had more than ample time to correct the mistake. Postaccident sight-distance tests showed that she would have had a partial view of the stopped train when the trains were still 1,037 feet apart. After traveling 127 feet farther, she would have had a full view of the rear of the train and its marker lights. After another 146 feet, she would have had an unobstructed view of the stopped train and would have been aware that it was on the same track as her train. At any of these points, she could have slowed her train and prevented the accident. In fact, the sight-distance tests showed that even if the operator had achieved a speed of 38 mph and waited until the trains were only 394 feet apart, she could have used normal (not emergency) braking to bring her train to a safe stop short of a collision.

Performance of the Operator of the Striking Train

The NTSB considered why the operator of the striking train did not comply with the signal indication and subsequently failed to take actions to avoid the accident even though she had ample opportunity to do so. Discounting an intentional and willful disregard for her own safety and that of the passengers, for which the investigation found no evidence, the only reasonable explanation is that the operator, during or slightly after beginning to accelerate out of Waban station, lost awareness of her environment.

The thorough autopsy performed on the operator by the state’s chief medical examiner revealed no preexisting medical condition that would have had the potential for causing this loss of awareness, and no postmortem evidence was found that the operator suffered a sudden medical event that would have precipitated a loss of consciousness. Instead, the evidence

indicates that the most likely explanation of the operator's loss of awareness is that she experienced a micro-sleep[2] episode shortly after departing Waban station.

The drug doxylamine, commonly found in over-the-counter sleep aids, was found in the operator's urine. This suggests that she might have taken the medication because she had some trouble sleeping during at least one of the several nights leading up to the accident but that she had not used the medication since the night before the accident at the latest. The operator was found to have a lesion on her abdomen that would likely have been painful enough to have interfered with her ability to gain restful sleep, and she may have taken the doxylamine to counter that pain or discomfort. The fact that the medication was not found in the operator's blood makes it unlikely that she would have been impaired by it on the day of the accident.[3]

The circumstances of this accident included several additional factors that placed the operator at risk for diminished alertness and for subsequently lapsing into episodes of micro-sleep. The 5:51 p.m. time of the accident coincided with the later afternoon low of the human circadian rhythm, a time of day in which studies have shown that individuals can fall asleep rapidly.[4] Moreover, the low level of muscular activity required of the seated operator and her relatively low workload are both factors that have been established as contributors to diminished alertness.[5]

Based on the operator's height and weight at the time of her last physical examination, she had a calculated body mass index (BMI) of 38.6. By this calculation, the operator would have been considered obese (a BMI greater than 30 constitutes obesity). Obesity is significantly associated with an increased risk for obstructive sleep apnea. In one study, obstructive sleep apnea was exhibited in more than 50 percent of patients with an average BMI of 40.0.[6]

Obstructive sleep apnea is associated with fatigue and significant cognitive and psychomotor deficits that are at least partially reversible with appropriate treatment.[7] Accident rates have been shown to be considerably higher in drivers with obstructive sleep apnea than in those without the disorder.[8] The Federal Motor Carrier Safety Administration (FMCSA) medical

---

[2] A *micro-sleep* is an episode of sleep that may last from a fraction of a second up to 30 seconds or more. Although often associated with sleep disorders such as sleep apnea, narcolepsy, or hypersomnia, episodes of micro-sleep can occur in any individual suffering from fatigue or inadequate sleep.

[3] The presence of the medication in the operator's urine but not in her blood indicates that the medication had already been metabolized and that its effects had subsided.

[4] U.S. Congress, Office of Technology Assessment, *Biological Rhythms: Implications for the Worker*, OTA-BA-463 (Washington, DC: U.S. Government Printing Office, September 1991).

[5] M. Moore-Ede, *The Twenty-Four Hour Society: Understanding Human Limits in a World That Never Sleeps* (Reading, MA: Addison-Wesley Publishing Company, 1993).

[6] O. Resta and others. "Sleep-Related Breathing Disorders, Loud Snoring and Excessive Daytime Sleepiness in Obese Subjects." *International Journal of Obesity-Related Metabolic Disorders*. May 2001; 25(5): pp. 669-675.

[7] L. Ferini-Strambi and others. "Cognitive Dysfunction in Patients with Obstructive Sleep Apnea (OSA): Partial Reversibility After Continuous Positive Airway Pressure (CPAP)." *Brain Research Bulletin*. June 30, 2003; 61(1): pp. 87-92.

[8] J. Teran-Santos, A. Jimenez-Gomez, and J. Cordero-Guevara. "The Association Between Sleep Apnea and the Risk of Traffic Accidents." Cooperative Group Burgos-Santander. *New England Journal of Medicine*. March 18, 1999; 340(11): pp. 847-851.

review board recently recommended that the FMCSA require screening for obstructive sleep apnea in all drivers with a BMI over 30. The NTSB concludes that the operator of the striking train was at a high risk for having undiagnosed sleep apnea, and she may have been chronically fatigued as a result of the condition.

Once the operator had departed Waban station, she likely would have had no operational matters to attend to other than those routine and long-practiced tasks, such as controlling train speed, that would almost be second nature to an experienced person operating along a familiar route. Such a low demand on her mental resources, in concert with fatigue from poor sleep quality due to discomfort and/or to undiagnosed sleep apnea, likely caused her to become relaxed and to disengage from her environment consistent with lapsing into a micro-sleep sometime after she departed Waban station. It is possible that if she observed the red signal at Waban station, she proceeded based on the belief that any train ahead would clear by the time her train arrived. She may have intended to hold her train's speed below 10 mph through the block, but during an episode of micro-sleep, the train would have continued to accelerate. The NTSB therefore concludes that the operator of the striking train failed to respond appropriately to the controlling signal indication or to take advantage of several opportunities to slow or stop the train and to prevent the accident likely because she experienced a micro-sleep episode after departing Waban station.

In its investigation of an August 15, 2000, accident involving the Maryland Transit Administration Central Light Rail Line System at the Baltimore-Washington International Airport light rail transit station,[9] the NTSB identified as an element of the probable cause the previously undiagnosed obstructive sleep apnea of the train operator. The condition caused the operator to fall asleep and fail to brake the train before it stuck a bumping post at the terminus.

As a result of that accident investigation, the NTSB issued the following safety recommendation to all U.S. rail transit systems:

> R-01-27
>
> Ensure that your fatigue educational awareness program includes the risks posed by sleeping disorders, the indicators and symptoms of such disorders, and the available means of detecting and treating them.

In March 20, 2002, and June 18, 2002, responses to Safety Recommendation R-01-27, the MBTA informed the NTSB that it did not have a formal fatigue awareness program but that, in response to the NTSB recommendation, it had completed an introductory fatigue awareness campaign and that:

> The Wellness Program will continue to provide informational material to our employees. In addition, the MBTA University's Wellness Institute will collaborate with the Operations division in designing a fatigue education program.

[9] *Maryland Transit Administration Light Rail Vehicle Accidents at the Baltimore-Washington International Airport Transit Station Near Baltimore, Maryland, February 13 and August 15, 2000*, Railroad Special Investigation Report NTSB/SIR-01/02 (Washington, DC: National Transportation Safety Board, 2001).

The MBTA also responded that its medical clinic would "enhance" its data collection sheets "to include specific questions on the signs and symptoms of sleep disorders."

Based on these responses, the NTSB, on May 17, 2002, classified Safety Recommendation R-01-27 "Open—Acceptable Response."

During the investigation of the Newton, Massachusetts, accident, NTSB investigators examined material currently provided formally by the MBTA to its train operators with regard to fatigue and sleep disorders. This material consisted of a single audio-visual slide titled "Fatigue/Drowsiness" and a single paragraph in the current *Green Line Light Rail Vehicle Operation Defensive Driving Manual.* The paragraph in the operator's manual quotes the text of the audio-visual slide and states, in part:

> All you need to do is get enough rest. Most people need 8 hours of sleep per night. Know what sleep you require and take care of yourself by getting the proper rest.

Based on the examination of these materials, the NTSB believes that the MBTA continues to have a fatigue awareness program that fails to adequately address potential sleep disorders among its train operators. Thus, the agency has not appropriately responded to the intent of Safety Recommendation R-01-27.

With regard to revisions or enhancements the MBTA indicated to the NTSB that it would make to its medical data collection form, the form continues to lack any inquiries about sleep disorders, snoring, or any difficulties with sleep. Such inquiries could provide a basis for identifying train operators and others in safety-sensitive positions who are at risk for obstructive sleep apnea or other disorders so that those individuals can receive additional evaluation and, if necessary, appropriate treatment.

The NTSB concludes that the MBTA continues to have an inadequate fatigue awareness program to educate train operators about the risks of fatigue and an inadequate program to identify and address potential sleep disorders for its train operators. The NTSB believes that the Federal Transit Administration (FTA) should promote awareness, throughout the transit industry, of the safety risks associated with sleep disorders and should assist transit agencies in developing programs to minimize that risk. The NTSB therefore recommends that the FTA develop and disseminate guidance for operators, transit authorities, and physicians regarding the identification and treatment of individuals at high risk for obstructive sleep apnea and other sleep disorders.

Positive Train Control

Four decades of NTSB investigations of railroad accidents have shown that the most effective means of avoiding train-to-train collisions is through use of a positive train control system that will automatically stop a train if the crew fails to comply with a signal indication. Previous investigations have identified a wide range of factors that can affect a train crew's response to signal indications, such as multiple simultaneous distractions, cell phone usage, dense fog, crew inattention, use of prescription medications, and fatigue.

This accident in Newton, Massachusetts, is another in a long series of accidents that could have been prevented had the territory been equipped with a positive train control system.

Such a system could have detected that train 3667 was operating above the allowable speed of 10 mph as required by the signal indication at signal H-64 and could have provided an over speed warning or stopped the train if the operator failed to comply with the signal indication. The NTSB therefore concludes that this accident could have been prevented had the MBTA Green Line been equipped with a positive train control system that could have intervened to stop train 3667 before it could strike the rear of train 3681.

The Rail Safety Improvement Act of 2008 requires each class I, intercity, and commuter rail carrier (carriers regulated by the Federal Railroad Administration) to develop and submit to the U.S. Secretary of Transportation, within 18 months, its plan for the implementation of a positive train control system by December 31, 2015. Transit agencies that operate trolley, light rail, and heavy rail systems are not included in the requirements of the Rail Safety Improvement Act of 2008. The NTSB therefore recommends that the FTA facilitate the development and implementation of positive train control systems for rail transit systems nationwide.

Therefore, the National Transportation Safety Board makes the following recommendations to the Federal Transit Administration:

> Facilitate the development and implementation of positive train control systems for rail transit systems nationwide. (R-09-8)
>
> Develop and disseminate guidance for operators, transit authorities, and physicians regarding the identification and treatment of individuals at high risk for obstructive sleep apnea and other sleep disorders. (R-09-9)

The NTSB also issued safety recommendations to all U.S. rail transit agencies and the Massachusetts Bay Transportation Authority.

In response to the recommendations in this letter, please refer to Safety Recommendations R-09-8 and -9. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our Tumbleweed secure mailbox procedures. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Acting Chairman ROSENKER and Members HERSMAN, HIGGINS, and SUMWALT concurred in these recommendations.

[Original Signed]

By: Mark V. Rosenker
Acting Chairman